Alternative catalysts offer high activity, low cost

OAAT ACCOMPLISHMENTS

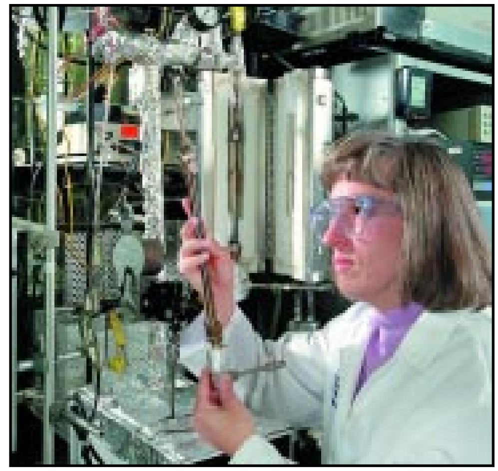
Improved Water-Gas Shift Catalysts

Challenge

Development of fuel-flexible, onboard fuel processors will facilitate introduction of fuel cell vehicles by enabling use of gasoline and alternative fuels. In addition to the hydrogen used to generate electricity, the fuel reformer generates carbon monoxide (CO) as a byproduct. This CO is converted to additional hydrogen by the water-gas shift (WGS) reaction:

$$CO + H_2O \_ CO_2 + H_2$$

The WGS reaction proceeds at either high temperature shift (HTS), (350-450° C), or low temperature shift (LTS), (160-250° C). Conventional HTS catalysts are inactive below 300° C, while conventional LTS catalysts degrade above 250° C. Both catalysts require activation by *in situ* pre-reduction steps. Since both catalysts burn up when exposed to air (pyrophoric), they must be sequestered during system shutdown when only air flows through the system. In addition, conventional shift reactors are the largest component of the fuel processor, impacting fuel processor size, weight, and start-up time. Low-cost, air-stable water-gas shift catalysts with high activity are needed.



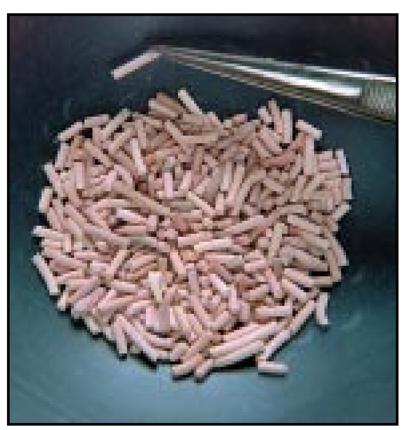
Research focused on bifunctional catalysts.

Technology Description

This project explored alternative WGS catalysts that:

- Did not need to be activated *in situ*;
- Were not pyrophoric, and thus, did not need to be sequestered during system shutdown; and,
- Were tolerant to temperature excursions.

Work focused on bifunctional catalysts, where one component of the catalyst adsorbs or oxidizes CO to CO_2, while the other dissociates water to H_2 and donor oxygen for oxidation. Three alternative bifunctional catalysts have been tested: platinum/mixed oxide, non-precious metal/mixed oxide, and vanadium-cobalt oxides.



Platinum/mixed oxide catalyst.

Accomplishments

- Argonne National Laboratory has developed platinum/mixed oxide and non-precious metal/mixed oxide water-gas shift catalysts having activity greater than commercial LTS copper/zinc oxide.
- These catalysts are active up to 400° C. The platinum/mixed oxide does not lose its activity when exposed to air at temperatures up to 550° C, while the non-precious metal/mixed oxide is tolerant to air up to 230° C.

Contacts

JoAnn Milliken
Manager, Fuel Cells R&D
202-586-2480
202-586-9811 fax
JoAnn.Milliken@ee.doe.gov

Deborah J. Myers
Argonne National Laboratory
630-252-4261
630-2552-4176 fax
myers@cmt.anl.gov

- The higher activity of the catalysts means that a 50-kWe fuel cell system would require a WGS catalyst volume of 13.5 L, a 30% reduction from the 19.2 L volume required for a conventional catalysts.
- The platinum/mixed oxide catalyst has been able to reduce inlet 10% CO to exit CO concentrations of less than 1% CO from diesel, and to 1.1% CO from simulated reformate.

Benefits

- Alternative bifunctional WGS catalysts do not lose activity when exposed to air and are active at temperatures up to 400° C. This reduces the complexity of WGS systems, since catalysts do not have to be protected from temperature excursions or system shutdown.
- Catalyst material costs have been reduced by increasing the activity of alternative catalysts, which allows the loading of active catalysts onto inert substrates to be reduced. Lower loading allows smaller volumes of catalyst to be used to achieve the same level of WGS activity. Smaller volumes not only reduce material costs, but also allow more flexibility in the placement of WGS systems in a vehicle.

Future Activities

Future work will determine the durability and stability of metal/mixed oxide catalysts under typical reformate conditions, including exposure to sulfur. Measures to increase the low-temperature activity of non-precious metal catalysts will be pursued. Vanadium-cobalt oxide catalysts will be prepared in more active, high-surface-area forms. Other metal/mixed oxide and bimetallic/polymetallic combinations will be explored. Catalyst fabrication equipment will be developed to supply industry with large enough quantities to evaluate.

Partner in Success

- Argonne National Laboratory